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Uncertainty and the Discrepancy between Rate-of-Return Estimates at Project Appraisal and Project Completion

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and
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This statistical survey of more than 1,000 World Bank projects reveals a sharp divergence between estimated rates of return at appraisal and at project completion. Traditional methods of project evaluation and selection have been unable to reduce the high degree of uncertainty associated with project analysis.

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Pohl and Mihaljek analyze the World Bank's experience with project analysis from a sample of 1,105 projects. They compare estimated rates of return at appraisal with re-estimated rates of return at project completion (that is, at the completion of construction works, usually five to ten years after appraisal).

Their findings confirm a high degree of uncertainty in project analysis. Only a small part of the discrepancy between estimated rates of return at appraisal and the re-estimated rates of return at project completion can be explained, even with the benefit of hindsight.

World Bank appraisal estimates of rates of return are too optimistic. But, explain Pohl and Mihaljek, factors usually associated with this optimistic bias (cost overruns, implementation delays) seem to explain only a small part of unexpected changes in project performance.

Uncertainties seem to be higher in the directly productive sectors (agriculture and industry), where rates of return can be altered through external market forces or domestic policy shocks. Estimated rates of return seem more stable for infrastructure projects.

One alternative to correcting modal estimates of implementation variables for "bad surprises" might be to set different minimum rate-of-return criteria for different types of projects (10 percent for transport, for example, but 15 percent for agricultural and industrial projects), based on observed divergences in rate of return.

Project analysis simply has to cope with a large degree of uncertainty. Traditional methods of project evaluation and selection have been unable to reduce this large measure of uncertainty.

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Introduction

1. Over the past decades, cost-benefit analysis has become a standard appraisal tool for selecting development projects at the World Bank and other development finance institutions. A number of governments also have adopted these techniques in the planning of public investment projects. In terms of methodology, the World Bank broadly follows Little-Mirrlees (1968, 1974), who expanded earlier approaches to cost-benefit analysis to take account of economic distortions typically prevailing in developing countries, including overvalued exchange rates, tariffs and quantitative import restrictions, high commodity taxes, and a general shortage of savings, particularly for public sector investment projects. Squire and van der Tak (1975) refined the methodology further to take account of income distribution effects. More recent generalizations and refinements of the theory of cost-benefit analysis are reviewed, for example, in Drèze and Stern (1987) and Squire (1989).

2. The main features of the Little-Mirrlees methodology include: (a) measuring all costs and benefits at economic (shadow) prices; (b) using international prices for traded goods; (c) decomposing non-traded goods into their constituent inputs and valuing each at its shadow price; (d) using shadow wage rates that reflect the output foregone in alternative uses and the higher value of public, compared to private, income; (e) discounting net social benefits with an "accounting rate of interest" that would just ration

investment projects in the whole economy to the funds available 1/; and finally, (f) uncertainty is to be taken into account only to the extent that profitability is expected to be correlated with the general state of the economy (Little and Mirrlees, 1990).

3. While the theory of cost-benefit analysis provides a rigorous conceptual framework in which to evaluate public expenditure programs and investment projects, practical applications depart quite substantially from these ideals, as some of the key parameters are difficult to estimate in practice. In theory, for example, net discounted benefits at the "accounting rate of interest" would be the appropriate criterion to decide whether to carry out a particular project in the Little-Mirrlees framework. In practice, it is quite difficult to estimate the "accounting rate of interest" reasonably accurately (see e.g., Ray). Equating the accounting rate of interest with the (highest) rate that just exhausts available investment funds, as suggested early on by Little and Mirrlees, is conceptually clear and simple, but few, if any, developing countries have a comprehensive ranking of available public investment opportunities. Returns on past public sector investments may be misleading due to poor investment decisions or inappropriate economic policies. Project proposals by sectoral agencies, on the other hand, may be "padded" with optimistic assumptions and imply an exaggerated rate of return.

1/ The type of discount rate to be used in cost-benefit analysis is closely associated with the choice of the "numéraire". In the Little-Mirrlees framework, the numéraire is "uncommitted public income", and the "accounting rate of interest" is linked to the opportunity cost of capital as well as the consumption rate of interest. In the alternative UNIDO formulation (Dasgupta, Marglin, and Sen) the numéraire is consumption and the appropriate discount rate is thus the consumption rate of interest (see e.g., Ray or Squire).

4. For these and other reasons, the World Bank follows the Little-Mirrlees methodology only broadly. Border prices are generally used for traded goods, and non-traded goods are decomposed into direct cost elements (see, e.g., Inter-American Development Bank for a practical guide to calculating sectoral shadow prices). Distributional weights, although pioneered at the World Bank, are rarely used in practice. Since public-sector and economy-wide rate-of-return estimates vary considerably across countries (depending on endowments and, more importantly, policies), the Bank uses the "internal rate of return calculated at shadow prices" or, short, the "economic rate of return" as an important, but not exclusive, decision criterion. With few exceptions, the World Bank only finances projects which have an estimated economic rate of at least 10% at appraisal (in constant prices). A somewhat odd departure from the principles of cost-benefit analysis has been adopted in the electric power sector, where benefits are measured not at shadow prices (marginal costs), but at actual tariffs, which may considerably underestimate benefits (and thus economic rates of return) in this sector 2/.

5. The Bank's long history of project financing provides a unique opportunity to quantify the level of uncertainty in public sector investment projects in developing countries and to assess the effects of cost-benefit analysis on investment decisions. For projects that are reasonably amenable to quantification of costs and benefits, Bank staff calculate economic rates of return at appraisal and again at project "completion", that is, after

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2/ This does not imply inappropriate investment or financing decisions, since power project proposals usually are based on a least-cost investment programming exercise. It only underestimates rates of return of power projects.

construction works have been completed and the project enters into normal operations.

6. For more than one thousand projects, economic rate of return estimates now are available for both appraisal and "completion" (or "start-up"). The difference between these two estimates provides an interesting empirical measure of uncertainty of development projects financed by the World Bank. 3/ It should be noted that the re-estimated rates of return are not yet true ex-post rates of return, since they are made at the start-up of normal operations. In view of the long life of most investment projects, ex-post estimates can only be made in another twenty or thirty years. Re-estimated rates of return should, however, be closer to true ex-post rates of return, as the effect of a number of risks already is known (investment costs, construction delays, initial operating performance, etc.), and later costs and benefits are more heavily discounted. 4/ However, due to the long life of most investment projects, the relationship between ex-post rates of return and

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3/ Of course, projects financed by the World Bank are not necessarily representative of public sector investments in developing countries. Projects submitted by Governments for Bank financing may primarily include projects with above-average rates of return and below-average risks. This may be particularly true in large countries (such as India), where World Bank financed projects represent only a very small part of the public investment program.

4/ The re-estimated rate of return is calculated by the Bank's organizational unit which has appraised and supervised the implementation of the project. Due to normal staff turnover (rotation), appraisal and re-estimates are usually made by different project officers. The staff turnover may improve the honesty of the re-estimate, but, at the same time, it may lead to methodological differences. The effect of these factors on the rate of return gap is not known.

re-estimated rates at completion of construction may be as loose as the relationship between appraisal and re-estimated rates of return.

7. While a considerable degree of uncertainty is to be expected in the implementation of development projects, the extent of revealed uncertainty in World Bank projects is striking. Estimates of economic rates of return at appraisal (AERR) are relatively poor predictors of re-estimated rates of return (RERR) at completion of construction works, with appraisal estimates explaining only about 20% of the variation in the re-estimated rates of return. Figure 1 shows this relationship graphically. Projects with appraisal or re-estimated economic rates of return over 40% - about 8% of all projects - have been omitted for greater clarity.

8. The remainder of this paper analyzes the differences between appraisal and re-estimated rates of return with statistical techniques and provides some initial interpretation of the results. Of course, the statistical analysis can only capture factors that are measurable and are applicable to all types of projects. This approach only can provide an overview and cannot substitute for project performance audits at the project level. The rate of return of a copper project, for example, will depend strongly on whether actual copper price developments fulfill appraisal expectations. The closest our analysis gets to this is through inclusion of a composite real commodity-price index on projects in broad sectors (e.g., agriculture).

Figure 1: Relation Between Appraisal and Re-estimated Rates of Return

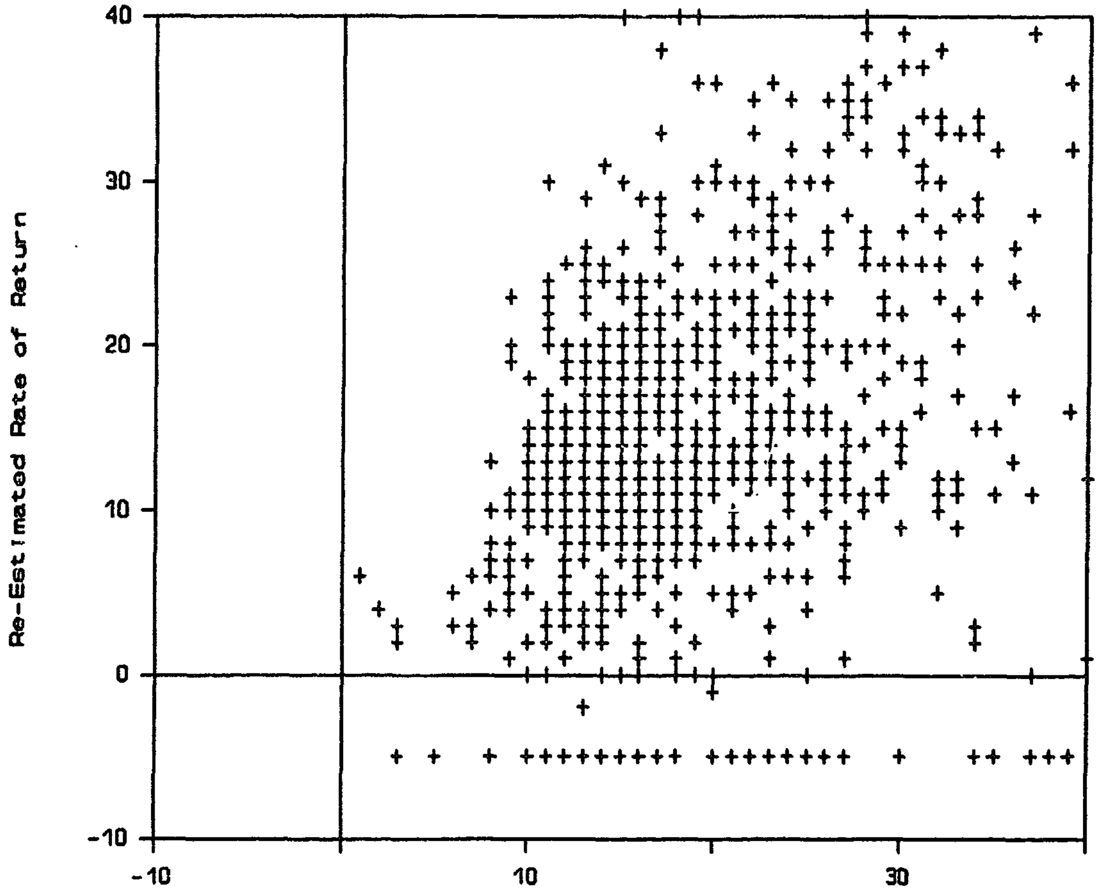

Figure land

A. Methodology

The Data

9. The analysis in this paper is based largely on a data base maintained by the Bank's Operations Evaluation Department (OED), an independent unit reporting directly to the Executive Directors. The complete data set includes 2,200 projects for which "project completion reports" had been issued during

1974-1987 by the respective project department for audit by OED on a sample basis. For slightly more than half of these projects, economic rates of return have been calculated by the staff at appraisal and project "completion" (start-up of normal operations). For the remainder of the projects in the data base, economic rates of return were not available, primarily because quantification was deemed infeasible or unjustified. Examples include a large number of small technical assistance credits, reconstruction loans financing imports after natural or man-made calamities, structural adjustment loans in support of policy reforms, and lines of credit to financial institutions (for the latter, rates of return are calculated for sub-projects, but are not aggregated). A small number of projects were excluded because other key variables were missing from the data set, or because other supplementary data were not available (for example, because the project financing has been canceled by the recipient, or because the country has ceased to report economic data). The analysis thus was carried out with a final sample of 1,015 projects for which a complete data set was available. The sample selection is thus fairly objective and does not appear to bias the results. The only systematic omission is financial intermediation projects, financing numerous small and medium-scale industrial and agricultural projects. A similar analysis could, in principle, be carried out for financial intermediation projects, but would involve considerable data collection efforts.

10. The OED data base was augmented by supplementary variables that were believed to be important explanatory factors of project success, including the Bank's internal ranking of economic management performance by country as of

1978, a country-specific index of price distortions for the 1970s (constructed by Agarwala 1983), real commodity-price movements, per capita income, and adult literacy rates. The price distortion index was available for 31 countries accounting for 612 projects. A separate analysis was undertaken for this smaller sample. Sectoral and regional dummy (0,1) variables also were introduced as proxies for project characteristics and management performance.

11. Table 1 presents the main descriptive statistics for the data set and shows the wide variety of projects. Economic rates of return are derived, as explained above, as real internal rates of return at economic (shadow) prices. Project costs in the data base are in nominal US dollars and range from about $1 million to over $4 billion. The largest number of projects is in agriculture (40%), followed by transport (30%), energy (20%) and a small number of projects in industry and urban development. The larger part of the Bank's industrial lending is intermediated through financial institutions. Unfortunately, average rates of return on financial intermediation lending are not systematically available. With the exception of construction costs, the medians are fairly close to the averages for the data set. Constant-dollar cost data are not recorded in the data base, although they are available in the project files and have been used to calculate the economic rates of return. Rather than sifting through 1,015 voluminous project files, we have estimated implicit real costs from forecast and actual price developments as well as from other implementation data in the data base (see the Annex).

Table 1: Summary Statistics for 1,015 World Bank Projects

	Mean	Median	Maximum	Minimum	Standard Deviation
Economic Rate of Return (%)					
At appraisal	22	18	158	1	13
At project "completion"	16	14	128	-20	13
Total Project Cost (mil. US $, current prices)					
At appraisal	86	34	3,193	1	185
At project completion	102	40	4,045	1	233
Nominal cost overrun (%)	22	10	514	-89	46
Unexpected inflation (%)	20	23	38	-2	7
Real cost overrun (%)	-6	-11	394	-91	34
Time overrun (years)	2	2	16	-4	2
Time overrun (%)	58	46	405	-68	56

12. There is considerable variation in the appraisal rates of return, ranging from only 1% for a water supply project in Bombay, to 158% for a seed project in India (which, by the way, had a re-estimated rate of return at project completion of only 11%). The wide range of rates of return both at

appraisal (1% to 158%), and project "completion" (-20% to 128%) 5/ is perhaps surprising. In the more orderly world of economic theory and model-building, one usually assumes that rates of return converge within a fairly narrow range. Ninety percent of all projects have appraisal rates of return in the range of 10-40%, but only about half have re-estimated rates of return within this range, highlighting the importance of uncertainty. The average rate of return of World Bank projects has behaved in a more orderly way, averaging 22% at appraisal and 16% at project completion (Table 1), with fairly small differences from year to year.

13. World Bank projects have, on average, taken considerably more time to implement (six years) than expected at appraisal (four years), and project costs in US dollars were, on average, 22% higher than estimated at appraisal, despite ample physical and price contingencies built into project cost estimates. Project cost overruns and implementation delays thus could be important factors in explaining project performance and the loose relationship between rate-of-return estimates at appraisal and project completion.

5/ For about 5 percent of all projects the re-estimated (internal) rates of return are negative. For many projects with negative rates of return these are given as -5% in the data base, presumably because negative internal rates are highly sensitive to small differences in assumptions, and truncation of the time horizon. Reasonably realistic assumptions will in most cases lead to small (rather than large) negative numbers, as long as failed projects yield some small excess of benefits over variable costs (i.e. disregarding the initial investment costs). For example, at a discount rate of -10%, a benefit of $ 1 in year 20 would be compounded to $ 6.7, or 45 times its present value at discount rate of +10%. However, if this small benefit is disregarded, the calculated internal rate of return is minus infinity. The economic interpretation of negative internal rates of return in most cases is a zero rate of return (no increase in output for some large investment). Only if variable costs exceeded benefits (both at shadow prices) would one normally speak of "negative" rates of return. The latter case typically would be due to domestic price distortions (negative value added at international prices).

14. While the <u>average</u> re-estimated rates of return are satisfactory (15.8%, vs. 21.6% at appraisal), there is a large number of projects with low returns (25% of all projects have re-estimated rates of return below 10%; 14% below 5%; and 8% of all projects have zero or negative rates of return). This suggests that considerable benefits could be obtained if it were possible to identify the factors that lead to project failure. Defining project "failure" is not a simple matter. Some cut-off point for rates of return has to be adopted to distinguish successful from unsuccessful projects. In the Little/Mirrlees framework, that cut-off point would be relatively high (say 10%) due to the choice of the numéraire (scarce "uncommitted public income").

15. With the help of the derived real project costs (Annex), the reported nominal cost overruns were decomposed into two parts: (a) unexpected changes in the general price level for capital goods; and (b) project-specific real cost increases. The latter could be due either to an error in project cost estimates, unforeseen difficulties and expenditures, or increases in the scope of projects. Nominal cost overruns mostly are explained by unexpectedly high inflation during the period (primarily the 1970s), with actual prices being 19.8% higher than projected at appraisal. Perhaps surprisingly, the appraisal cost estimates were, on average, too high in <u>real terms</u>. Nominal cost overruns thus are primarily due to unexpectedly high inflation. Real cost variations range from -90% (probably largely due to cancellations of project components) to increases of nearly 400% (probably reflecting mainly expansion in the scope of projects, rather than faulty cost calculations).

Statistical Methodology

16. The divergence between the appraisal and re-estimated rates of return has been analyzed with two types of linear regression. The first consists of regressing the re-estimated rates of return at project "completion" (i.e., at the completion of construction and the start-up of normal operations) on the appraisal rates of return and a number of other factors that are thought to influence project performance. Since both the appraisal and re-estimated rates of return depend on the same set of other factors, this approach is best interpreted in terms of a "seemingly unrelated regression" model. 6/

17. One statistical problem with the standard ordinary least squares (OLS) estimation of this linear regression model is that residuals calculated from the above data set do not have uniform variance and zero correlation with one another, i.e., they are not homoskedastic. In the presence of heteroskedasticity the OLS estimator remains unbiased, but it no longer has minimum variance among all linear unbiased estimators. Also, the usual formula for the variance-covariance matrix of OLS estimators is incorrect, and, therefore, the usual estimator of their variance is biased, implying that interval estimation and hypothesis testing using these estimators no longer can be trusted. 7/

6/ See Zellner (1962) for the original contribution; and Wallace, Duane, and Nawaz (1987) for an application similar to this article.

7/ Intuitively, one would expect larger time and cost overruns to be associated with larger rate-of-return discrepancies. For a wide range of projects, the standard deviation of re-estimated rates of return increases only moderately with appraisal rates of return (from 9 percentage points for projects with AERR's of 10-20%, to 14 percentage points for projects with AERR's of 30-40%), but it jumps to 25 percentage points for a small number of projects with higher AERR's.

18. Although a number of techniques exist to correct the standard errors of estimates (see e.g., White, 1980), one can more easily eliminate the problem by transforming variables in such a way that the error term is constant. Thus, in the second type of regression model used in this paper we take as the dependent variable the percentage change of re-estimated over the appraisal rate of return (Y = (RERR - AERR)/AERR). This transformation eliminates heteroskedasticity, but at cost of losing interesting information about the relationship between the appraisal and re-estimated rates of return. 8/ For this reason we shall report the results from both types of regression.

19. Besides heteroskedasticity, the nature of our data set gives rise to another statistical problem - censoring of re-estimated rates of return. Although from the Table 1 it appears that the range of variation of re-estimated rates of return is wide enough to make plausible the assumption of an approximately normal distribution of residuals, in reality there is a considerable piling up of RERR's at a cutoff point of -5 percent. 9/ This reflects the established practice in the World Bank, whereby a project deemed

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8/ A third approach is to eliminate projects with very high appraisal rates of return, as these may have an extraordinarily strong influence over the results. Projects with such high appraisal ERRs often are due to major changes in expectations and usually involve comparatively small investments (e.g. energy conservation, resource discoveries, technological breakthroughs).

9/ About 7 percent of projects are assigned this rate of return.

to be a complete failure usually gets a -5 percent rate of return at completion. 10/

20. From an econometric point of view, the presence of this cutoff point implies that we are dealing with a censored sample, as some observations of the re-estimated ERR that correspond to known values of time and cost overruns are not observable, being instead arbitrarily assigned the RERR of -5 percent. The difficulty with OLS estimation based on censored data samples is that the least squares estimators of regression parameters are biased and inconsistent, using either the entire sample or the subsample of complete observations. 11/ This kind of data are best analyzed within the framework of the censored regression model, also known as the Tobit model (see Tobin, 1958). A number of techniques are now available to estimate Tobit models (see, e.g., Amemiya, 1984). To generate more efficient parameter estimates we used the maximum likelihood technique, which yields estimators with several desirable asymptotic properties. 12/

10/ Another such practice is that projects with appraisal rates of return of less than 10 percent usually are not considered for approval. Theoretically, in the presence of this cutoff point the data set would be truncated: values of time and cost overruns and RERR's would be known only when AERR's at or above 10 percent were observed, so we could make no inference on the potential performance of projects that were not accepted for financing. However, in the data set there are 46 projects (4.5 percent of the total) that were approved even though they had AERR's less than 10 percent, so information on normally "unobservable" projects actually is not missing.

11/ For analysis of censored data samples see, e.g., Maddala (1983); or Judge, Hill, Griffiths, Lutkepohl, and Lee (1985).

12/ MLE estimators are asymptotically unbiased, consistent, asymptotically efficient, and distributed asymptotically normally. For maximum likelihood estimation see, e.g., Greene, 1990. MLE estimates of Tobit regression models in this paper were computed using the procedure LIFEREG in the SAS statistical package, version 6.06.

21. The Tobit regression model for our data sample is of the form:

$$y_i = x_i'\beta + e_i \quad \text{if} \quad y_i > k, \quad i = 1,\ldots,T-s$$
$$= 0 \qquad \text{otherwise}$$

and the corresponding regression function is given by:

$$E(y_i|x_i,\ y_i > k) = X_i'\beta + \sigma\epsilon_i$$

where y is a vector of dependent variables (re-estimated ERR's, or percentage changes thereof over the AERR's); X is an nxk matrix of explanatory variables; β is a vector of unknown regression parameters; σ is an unknown scale parameter; e and ϵ are vectors of errors assumed to come from the standard normal distribution; k is the cutoff point (-5 percent for regressions where AERR is the dependent variable, and -1 for regressions where the dependent variable is (RERR-AERR)/AERR)); and s observations out of T are unobservable. 13/

B. Results

13/ The log likelihood function for this regression model is given by:

$$\ln L = -(n_1/2)[\ln(2\pi)+\ln\sigma^2] - (1/2\sigma^2)\Sigma_1(y_i-\beta'x_i)^2 + \Sigma_0\ln[1-\Phi(\beta'x_i/\sigma)]$$

where $\Phi(.)$ is the standard normal cumulative distribution function. First two parts of this function correspond to the classical regression for the noncensored observations, while the last part are the relevant probabilities for the censored observations. Although this is not the usual type of likelihood, Amemiya (1973) showed that proceeding in the usual fashion to maximize L produces estimators with all desirable asymptotic properties.

22. The simplest possible model is to relate only appraisal and re-estimated rates of return, assuming no other factors have been identified (Model 1):

$$RERR = a + b\ AERR + \sigma u$$

23. Maximum likelihood parameter estimates for this model are given in Table 2, where, for easier interpretation, we also included some summary statistics obtained from the OLS estimates of this regression. 14/ The results indicate that economic rates of return re-estimated at project completion are, on average, considerably lower than appraisal estimates (b = 0.44). The intercept is quite large (5.88 percentage points), indicating that re-estimated rates of return are somewhat higher, relative to appraisal estimates, for projects with low appraisal rates of return. A project with an appraisal rate of return of 10% has a re-estimated rate of return approximately equal to its appraisal rate of return (5.88 + 0.44 x 10 = 10.28%), while a project with an appraisal rate of return of 30% has, on average, a re-estimated rate of return of 19% (5.88 + 0.44 x 30). As indicated by the low values of standard errors of estimates, both the intercept and the parameter estimate for AERR are statistically highly significant. However, the appraisal rate of return explains only 19% of the variance, indicating a rather loose relationship between rate of return

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14/ Normal scale parameter σ does not have an intuitive economic interpretation, so its estimates will not be reported. In all regressions where the dependent variable is AERR, the estimates of σ are on the order of about 12 percentage points, and are statistically highly significant.

estimates at appraisal and completion of construction, already shown graphically in Figure 1.

<u>Cost Overruns and Implementation Delays</u>

24. Project cost overruns and implementation delays have at times been a considerable preoccupation of the Bank's management, as they have been intuitively linked with poor project performance. They are thus a logical point of departure in our analysis of rate-of-return divergences. Table 2 presents the results of regressions with re-estimated economic rate of return as the dependent variable, and various measures of cost overruns as independent variables. Model 2 introduces two variables from the data base, the nominal cost overrun (in percent), and the time overrun (in percent). However, both parameter estimates are small and statistically insignificant, indicating that nominal cost overruns and implementation delays do not seem to be major factors in explaining rate of return divergences.

25. Model 3 introduces two variables that decompose the nominal cost overrun into two components, unexpected inflation and real cost overruns. The real cost overrun parameter remains low and statistically insignificant, while the unexpected inflation variable is statistically significant. Since unexpected price increases have been expressed as negative numbers (reduction in the real value of available project resources), the parameter estimate implies that for projects with (the average) unexpected increase in the price level of 20%, rates of return have been reduced by 4.6 percentage points. The results seem to suggest that real increases in project cost have had no systematic effect on rates of return of World Bank projects, while unexpected

inflationary pressures have adversely affected the performance of Bank projects, perhaps because of relative price changes between capital-good inputs and project outputs.

26. This regression also yields a statistically significant estimate of the time overrun variable, which, surprisingly, has the "wrong" sign. If, for example, it takes an average project 58% more time to be completed than forecasted at appraisal, one can expect that this would improve the re-estimated ERR by about 0.7 percentage points. According to this result, the systematic bias towards underestimation of the time needed for project completion may be based on the wrong intuitive assumption that long periods of implementation are bad for project performance. However, the modest positive effect that time overruns have on project performance must be weighted against the much bigger negative cost effects stemming from unexpected inflation.

27. Only the introduction of the decomposed cost-overrun variables in Model 3 improves the regression fit compared to the Model 1, as shown by the F-test for additional regressors. But the adjusted coefficient of determination (R^2) improves by only one percentage point (from 19% to 20%). The chi-square statistic for the White test (see White, 1980) indicates the presence of heteroskedasticity at the 1 percent test level.

Table 2: Regressions with Cost Overruns

Explanatory Variables:	Dependent Variable: Re-estimated Rate of Return (RERR) Model 1	Model 2	Model 3
Intercept	5.88	5.25	8.78
	(0.76)	(0.88)	(1.26)
Appraisal rate of return (%)	0.44	0.44	0.45
	(0.03)	(0.03)	(0.03)
Nominal cost overrun (%)		0.003	-
		(0.009)*	-
Time overrun (%)		0.009	0.012
		(0.007)*	(0.007)
Unexpected inflation (-%)			0.23
			(0.06)
Real cost overrun (%)			0.01
			(0.01)*
Statistics calculated from the OLS regressions:			
Adj. R^2	0.19	0.19	0.20
F-statistic	240	80	64.6
Chi-square statistic for the White test	13.1**	26.8**	40.8**
(Critical value for 1% level)	(9.2)	(21.7)	(29.1)
F-test of the regression	-	0.7	5.0(+)

Values in parentheses are the standard errors.
* Not significant at the 5 percent level.
** Presence of heteroskedasticity at the 1 percent level of significance.
\+ Regression fit improved with respect to the Model 1.

28. Table 3 presents the results of regressions with the transformed dependent variable, (RERR-AERR)/AERR; and the transformed explanatory variables, $(X_t - X_{t-1})/X_{t-1}$, where t denotes the relevant observation at the time of completion (e.g., the actual time of construction), and t-1 the appraisal estimate of that same variable:

$$(RERR-AERR)/AERR = a + b'[(X_t - X_{t-1})/X_{t-1}] + \sigma u$$

29. In the estimated regressions there is no heteroskedasticity present at the 1% test level, but nominal cost and time overruns are not statistically significant, and the estimated parameters have the "wrong" sign. The decomposition of nominal cost overruns into unexpected inflation and real cost overruns helps somewhat, as the parameter estimate for the unexpected inflation variable now is statistically significant and has the expected (positive) sign (faster than expected inflation is a negative number). An unexpected price increase of 20% (the average for the sample) would thus give rise to a 73 percent rate-of-return discrepancy (3.63x20). However, although Model 5 significantly improves the otherwise poor fit of Model 4, the total explained variance of only 3% remains surprisingly low.

30. Project-specific real cost overruns thus do not seem to affect ex-post rates of return as adversely as one would expect. This may be due to the possibility that projects with large real costs overruns (up to almost 400%) reflect mostly expansions of projects, rather than errors in cost estimates. To the extent that later project phases lead to efficiency gains, one would expect improvements in the rate of return from such mislabeled "real cost overruns."

Table 3: Regressions with Cost Overruns

Explanatory Variables:	Dependent Variable: (RERR-AERR)/AERR Model 4	Model 5
Intercept	-101.42	-40.76
	(7.89)	(12.72)
Nominal cost overrun (%)	0.07	-
	(0.11)*	-
Time overrun (%)	0.01	0.03
	(0.01)*	(0.08)*
Unexpected inflation (-%)		3.63
		(0.70)
Real cost overrun (%)		0.14
		(0.14)*
Statistics calculated from the OLS regressions:		
Adj. R^2	0.0012	0.032
F-statistic	0.59	11.029
Chi-square statistic for the White test	9.38	17.40
(Critical value at 1% level)	(15.1)	(21.7)
F-test of the regression	-	28.8(+)

Values in parentheses are the standard errors.
* Not significant at the 5 percent level of significance.
+ Regression fit improved with respect to the Model 4.

Primary Commodity Prices

31. Since about 40% of the projects in the sample are agricultural projects, unexpected changes in commodity prices might explain a substantial part of the rate of return gap. We have chosen the ratio of the Bank's real commodity price index for 33 primary commodities (excluding energy) at project completion, to the same index at the time of project appraisal, as a measure of the extent of unexpected commodity price changes during project

implementation. 15/ Since the Bank's real commodity price index is deflated by the price index of exports of manufactured goods of industrial countries (the "MUV" index), collinearity between the "unexpected commodity price changes" variable and the other price variables has been eliminated.

32. Table 4 gives the results of regressions with this additional explanatory variable. The estimate for the "unexpected commodity price changes" variable is statistically significant, and its inclusion improves the fit of regression, as measured by the F-test, with respect to Models 3 and 5. The explained variance (R^2) increases by about 1.5 percentage points, which is quite respectable compared to regressions with other variables, but the unexplained variance nevertheless remains very large. The parameter estimates imply that an unexpected decline in commodity prices by 10% would result in a reduction of the rate of return by 0.8 percentage points (Model 3A), or 12% (Model 5A). 16/ A similar analysis also was carried out for agricultural projects, using a real agricultural commodity price index, and the results were analogous. The use of individual commodity price indices (e.g., coffee price index for coffee projects) probably would show greater sensitivity of some types of projects to specific commodity price changes, but the number of

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15/ This measure again is based on an adaptive expectations model of price expectations at the World Bank (see the Annex).

16/ The unexpected commodity price changes are measured as an index number, so no change corresponds to the index value of 1.0, and a 10% change to the index value of 1.1 or 0.9; hence, for a 10% decline in expected prices, the RERR is expected to decline by 8.19x(1.0-0.9). Notice that in Model 5A the high estimated values of the intercept term (-160.58) and the commodity price parameter (118.95) actually must be set against each other for the zero expected price change to give, approximately ,the intercept term from Model 5. The same would hold true of Model 3A if the intercept estimate were statistically significant.

observations is too small to permit much further disaggregation. Also, many agricultural projects are multi-purpose projects (e.g., irrigation) for which the broad commodity price index may be more useful.

Table 4: Commodity Price Expectations

Explanatory Variables:	Dependent Variables: RERR Model 3A	(RERR-AERR)/AERR Model 5A
Intercept	0.96	-160.58
	(2.72)*	(27.23)
Appraisal ERR (%)	0.46	-
	(0.03)	-
Time overrun (%)	0.015	0.07
	(0.007)	(0.08)*
Unexpected inflation (-%)	0.19	3.06
	(0.06)	(0.70)
Real cost overrun (%)	0.006	0.09
	(0.01)*	(0.14)*
Unexpected change in commodity prices (%)	8.19	118.95
	(2.35)	(27.44)
Statistics calculated from the OLS regressions:		
Adj. R^2	0.214	0.045
F-statistic	54.9	11.9
Chi-square statistic for the White test	63.7**	23.7
(Critical value for 1% level)	(37.6)	(29.1)
F-test of the regression	6.8+	14.0+

Values in parentheses are the standard errors.
* Not significant at the 5% level.
** Presence of heteroskedasticity at the 1% test level.
\+ Regression fit improved with respect to models 3 and 5.

Economic Management Factors

33. A second set of factors that could help explain some of the divergence in rate-of-return estimates between the appraisal and completion of construction are the country-specific factors, such as the human resource endowment, the type of economic policies pursued by the government, the

efficiency of public administration, and so on. Of course, these are complex factors that are not easily measurable and we have to make do with a few quantitative indicators, such as adult literacy, per capita income, an index of price distortions for the 1970s (Agarwala, 1983) and the Bank's internal ranking of the quality of government's economic policies and management (as of 1978, taken as representative for the 1970s).

34. It should be noted that these factors should have been taken into account by project evaluators, and factored into the appraisal estimate of the rate of return, and, more importantly, into project design (for example, the extent of expatriate project management services employed to ensure the success of the project). The parameter estimates for these variables thus need to be interpreted as the degree to which project evaluators did <u>not</u> sufficiently take account of these factors. In all cases it can be reasonably assumed that project evaluators were aware of these country-specific factors at the time of appraisal. Only in the case of the Agarwala price-distortion index could one possibly argue that there is some "benefit of hindsight" at work, as the extent of price distortions and their negative consequences may not have been fully appreciated. But Agarwala's index is based mostly on relatively easily available economic data that (at least in their raw form) were already available at appraisal. Moreover, the Bank's internal rating of economic management performance is fairly closely related to the price distortion index (the coefficient of correlation between the two ratings is -0.67).

35. Table 5 presents the results of regressions with country-specific variables added. The implementation delay and the decomposed cost-overrun variables from Models 3A and 5A have been retained. Most of the new variables are statistically significant (the economic management performance ranking, and the price distortion index are used as alternative indicators).

Table 5: Country-Specific Economic Management Factors a/

Explanatory Variables:	Dependent Variables: RERR		(RERR-AERR)/AERR	
	Model 3B	Model 3C	Model 5B	Model 5C
Intercept	-11.47	0.2*	-194.05	-68.66*
Appraisal ERR (%)	0.46	0.47	-	-
Time overrun (%)	0.01*	0.01*/	-0.02*	-0.002*
Unexpected inflation (-%)	0.15	0.16	2.78	2.87
Real cost overrun (%)	0.003*	0.004*	0.18*	0.17*
Unexpected change in commodity prices (%)	9.49	9.60	103.58	105.46
New:				
Economic management rating b/	0.42*	-	6.07*/	-
Agarwala price-distortion index c/	-	-5.48	-	-63.46
Log (GNP)	1.84	2.06	10.12*	15.66
Adult literacy	-0.06	-0.07	-0.82	-0.93
Statistics calculated from the OLS regressions:				
Adj. R^2	0.23	0.24	0.05	0.07
F-test of new regressors	4.5+	7.2+	4.7+	7.9+

Values in parentheses are the standard errors.
* Not significant at the 5% level.
*/ Not significant at the 5% level, but significant at the 10%.
\+ Regression fit improved with respect to the Model 3A or 5A.

a/ All regressions in this table are run for 31 countries (612 projects) for which the Agarwala price distortion index was available.
b/ As of 1973, on a scale of 1 to 10; lowest actual rating is 2.
c/ Ranges from 1.14 for Malawi (lowest distortion), to 2.86 for Ghana (highest distortion).

36. Interestingly, the Agarwala price-distortion index performs statistically considerably better than the Bank's rating of economic management performance. This is surprising, since the latter is based on the same economic data plus management's judgments based on qualitative insights. Apparently, the relatively simplistic procedure of adding up price distortions works better than a careful review process using qualitative judgments. In all model specifications, replacing the economic performance rating with the price distortion index results in statistically significant parameter estimates, a higher R^2, and in considerably higher values of F-tests for inclusion the new regressors (see Table 5). For the actual range of the price distortion index (from 1.14 to 2.86), the parameter estimates imply a 9.4 percentage points (Model 3C) lower re-estimated ERR in a country with high price distortions (such as Ghana during the 1970s), compared to a country with low price distortions (such as Malawi). 17/ The adverse effects on project performance of government interventions through price controls, high tariffs, import restrictions, etc., thus have been considerably underestimated in World Bank project appraisals.

37. However, despite these rather high parameter estimates, poor economic management and price distortions explain only about 2% of the rate of return gap, inching the total explained variance (Model 3C) to only 24%. The other two variables (level of income and adult literacy) have been introduced as (albeit crude) indicators of the human capital stock, and their parameter

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17/ Calculated as -5.48x(2.86-1.14)=9.43. Another interpretation can be given in terms of the Model 5C. If, for example, the average ERR discrepancy in a low-distortion country is 20%, then one can expect a 42% discrepancy in a high-distortion country (20x[-63.46x(2.86-1.14)].

estimates are statistically significant. For a halving of per capita income from, say, \$1000 to \$500, ex-post rates of return are lower by about 1.4 percentage points (Model 3C); or about 11 percent (Model 5C). 18/ This suggests that the Bank's project evaluators have tended to overestimate project implementation capabilities in the poorest countries. Surprisingly, the parameter estimate for the adult literacy variable has the "wrong" sign, indicating that re-estimated rates of return are lower in countries with higher adult literacy rates (for similar projects and levels of income). This can be explained by the fact that countries with high rates of literacy tend to engage in projects involving more sophisticated technology, that brings higher rates of return, but at higher risk, so that the rate-of-return discrepancy also is greater.

Sectoral and Geographic Differences

38. There are a number of ways to analyze the differences between the various types of projects. One is to introduce dummy (0,1) variables comparing different groups of projects. Another approach would be to run the same set of regressions on different (sectoral or geographic) subsets of projects to see whether there are statistically significant differences in parameter estimates. Table 6 presents estimates of regressions with both sectoral and regional dummy variables added to Models 3B and 5B, now labeled "3D" and "5D", respectively. 19/ Agriculture and South Asia were selected

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18/ Calculated as 2.06(ln1000-ln500)=1.43; and 15.66(ln1000-ln500)=10.85.

19/ Although it would have been preferable to use Models 3C and 5C instead of 3B and 5B (as the Agarwala index performs better), this would have limited the sample to only 31 countries and 612 projects, instead of the entire sample of 1,015 projects.

as the standard to which other sectors and regions are compared, so parameter estimates for sectoral and regional dummy variables indicate, e.g., how the energy projects, or projects in the Mediterranean region, perform relative to agricultural projects in South Asia.

39. The explanatory power of both regressions increases considerably following on the introduction of dummy variables (from an adjusted R^2 of 0.21 to 0.31 in the case of Model 3D; and from 0.03 to 0.12 in the case of Model 5D). These variables thus contribute more to the improved regression fit than all the previously introduced variables together (with the exception of the appraisal rate of return in Models 1 to 3). There thus appear to be clusters of projects with similar characteristics and problems.

40. Parameter estimates for sectoral dummy variables show that projects in our data sample roughly fall into two categories. Since the estimates for the intercept (i.e., agriculture), energy, and industry all are insignificant, the results of Model 3D indicate that, other things being equal, projects with an appraisal rate of return of, say, 20 percent that are undertaken in these three sectors are expected to have a re-estimated ERR of about 9 percent, or 11 percentage points below the estimate. On the other hand, transport projects are expected to have a re-estimated ERR about 4 percentage points below the estimate (7.62 + [20x0.43]), and urban development projects about 2 percentage

Table 6: Regressions with Sectoral & Regional Dummy Variables

Explanatory Variables:	Dependent Variables: AERR Model 3D	Dependent Variables: (RERR-AERR)/AERR Model 5D
Intercept	0.45*	-175.15
Appraisal ERR (%)	0.43	-
Time overrun (%)	-0.007*	-0.07*
Unexpected inflation (-%)	0.12	2.55
Real cost overrun (%)	0.006*	0.12*
Economic management rating	0.83*	6.53
Log (GNP)	-0.50*	11.94*
Adult literacy (%)	-0.04*/	-0.73
Unexpected commodity price changes (%)	6.45	90.49
Sectoral Dummies:		
Energy	0.96*	27.41
Transport	7.62	63.58
Industry	-0.88*	-29.51*/
Urban	9.51	-8.55*
Regional Dummies:		
East Africa	-12.54	-94.82
CFA countries	-8.02	-52.88
Other West Africa	-9.92	-96.87
East Asia	-3.64	-24.24*
Mediterranean	-6.92	-62.33
Latin America	-7.11	-63.04
Statistics calculated from the OLS regressions:		
Adj. R^2	0.309	0.121
F-test of regression	13.6(+)	8.1(+)

* Not significant at the 5 percent level.

*/ Not significant at the 5% level, but significant at the 10% level.

\+ Regression fit improved with respect to Models 3B and 5B.

points below the estimate. 20/ Re-estimated rates of return for projects the transport and urban development sectors thus are generally closer to the appraisal rates of return than is the case for projects in agriculture, energy, and industry. This pattern probably reflects two factors: (i) the relatively simple technology and organization of transport and urban development projects, compared to industrial and energy projects; and (ii) the effect of international markets on industrial and agricultural projects. Projects producing traded goods seem to be exposed to a higher degree of downside risks, and this may be related to international competition (i.e., competitors in other countries may be more productive and this may lead to lower prices for outputs, and sharply lower returns).

41. Parameter estimates for regional dummy variables all have negative sign, implying that re-estimated rates of return are highest in South Asia (the standard of comparison), followed by the projects in East Asia, with slightly lower (3.6%) rates of return. Projects in Latin America, the Mediterranean, and the French African Community (CFA) are next on the list, while projects in East and West Africa (other than the CFA zone) have performed particularly poorly. The better performance of CFA members compared to other African countries points to the importance of the institutional framework and, in particular, the conservative fiscal and monetary policies. It is interesting to note that the project implementation performance in CFA

20/ This pattern is roughly confirmed by the results of Model 5D, where the greatest rate-of-return discrepancy is for industry, then for agriculture and energy projects, while transport projects again have the lowest ERR discrepancy. Correct interpretation of figures in Table 6 is more complicated, though, because we neglected the term $\sigma\epsilon_1$; the scale parameter for Model 3D is 11.4, and for Model 5D it is 113.

member countries during the 1960s and 1970s is comparable to the average of other developing countries (i.e., Mediterranean and Latin America), but very different from other African countries.

42. This is corroborated by an analysis of failed projects. Out of 80 "total" project failures (i.e. negative rates of return at project completion), 27 are in East Africa, with Tanzania alone accounting for 11 project failures. Failed projects largely are concentrated in agriculture, as nearly two-thirds of all project failures world-wide have been agricultural projects, particularly complex "new style" area or rural development projects started in the mid-1970s (see Table 7). Agricultural projects in Sub-Saharan Africa have experienced an unacceptable failure rate, with one-half of all projects in East Africa, and more than one quarter of all projects in West Africa yielding re-estimated rates of return below 5%. There is again a strong distinction in West Africa between CFA members and other countries.

Table 7: Project Failures by Regions & Sector

	Percentage of projects with re-estimated rates of return below:		
	10%	5%	0%
All Projects	**25.2**	**13.6**	**7.9**
East Africa	41.1	27.9	17.1
West Africa:			
CFA member countries	21.8	18.2	10.0
Other West Africa	37.5	19.6	16.1
Mediterranean	29.1	14.3	7.4
Latin America	25.1	10.2	5.1
South Asia	14.7	6.4	1.1
East Asia	12.5	5.2	4.2
Agricultural Projects	29.0	19.8	12.7
- in East Africa	61.4	52.9	37.1
- in CFA members	34.0	26.0	16.0
- in other West Africa	45.8	33.3	29.0

43. A more informative approach to the analysis of the regional performance of projects is to run regressions for each sector separately. Results of these regressions are presented in Table 8. To save space, only the results for Model 3D are shown. (The pattern of parameter estimates for Model 5D is similar.) Compared to the combined sample (Table 6), the disaggregated regressions by sector have fewer statistically significant parameters, and parameter estimates for some variables are very different from sector to sector. For the appraisal rate of return, the parameter estimates fall into two sets: relatively high (0.61 - 0.67) for infrastructure projects and low (0.21 - 0.25) for agricultural and industrial projects, indicating that downside risks are larger (or have been underestimated) in the directly productive sectors. Unexpected movements in primary commodities (excluding

energy) seem to have affected industrial projects even more than agricultural projects (most of the industrial projects in the sample are import-substituting raw materials projects - e.g. fertilizer industry).

Table 8: Regressions by Sector

Explanatory Variables:	Dependent Variable: AERR (Model 3D) Agriculture	Energy	Transport	Industry
Intercept	6.66*	10.26*/	7.36*	-15.55*
Appraisal ERR (%)	0.21	0.61	0.67	0.25
Time overrun (%)	-0.02*	0.002*	-0.01*	-0.02*
Unexpected inflation (-%)	0.11*	0.29	0.11*	-0.05*
Real cost overrun (%)	0.03	-0.02*	-0.01*	-0.04
Economic management rating	0.61*	1.17	0.52*	-1.72
Log (GNP)	0.82*	-1.21*	0.62*	2.35*
Adult literacy (%)	-0.09	0.03*	-0.03*	0.10*/
Unexpected commodity price changes (%)	11.12	1.92*/	4.36*	15.72
Regional Dummies				
East Africa	-18.18	-5.09	-12.83	-14.06
CFA countries	-12.64	2.91*	-10.38	-
Other West Africa	-17.37	-7.89	-6.33*/	-
East Asia	-3.29*/	-4.42*/	-7.65	5.24*/
Mediterranean	-6.34	-7.46	-7.38*/	-4.11*
Latin America	-8.34	-6.76	-6.97*/	-2.81*
Number of projects	411	216	310	56
Statistics calculated from OLS regressions:				
Adj. R^2	0.25	0.30	0.32	0.33
Adj. R^2 without regional dummies	0.11	0.29	0.29	0.03

* Not significant at the 5% level.
*/ Not significant at the 5% level, but significant at the 10% level.

44. Unexpected inflation seems to have affected particularly the more capital-intensive infrastructure projects, but may also reflect delayed adjustments in government price regulations in the case of the electric power

sector, where the Bank's methodology does not conform to the principles of cost-benefit analysis. The economic management rating also shows some perplexing sectoral differences, with a negative parameter estimate for industrial projects which may be the consequence of a few conspicuous project failures in countries with high performance ratings. A separate analysis for agricultural projects showed that the Agarwala price distortion index performs dramatically better than the economic performance ranking in that sector.

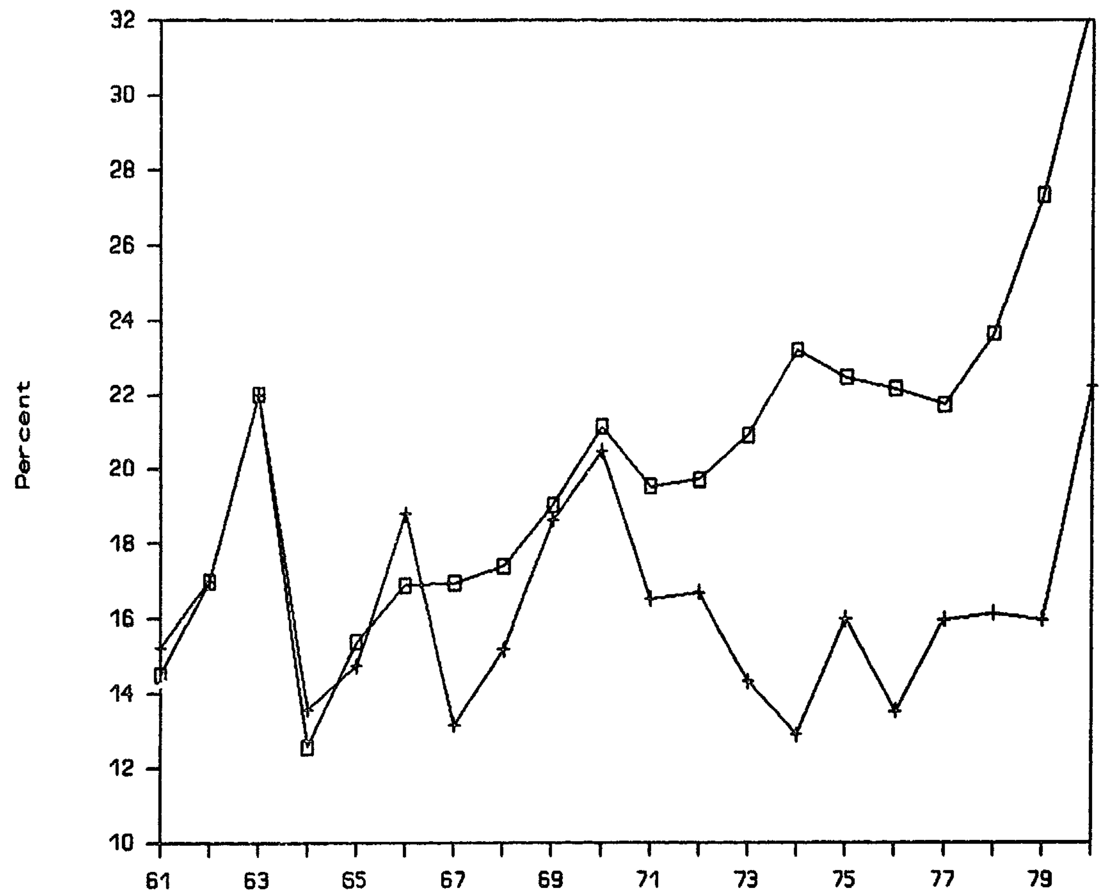
Trends over time

45. An analysis of appraisal and re-estimated rates of return by year of approval shows that the rate of return gap has increased considerably over time. Projects appraised in the 1960s showed little difference between average rates of return at appraisal and completion and annual variations were tracked quite closely. Appraisal and re-estimated rates of return started to diverge in the early 1970s. The main reason appears to have been increasing optimism of project evaluators, with average appraisal rates of return rising from about 16% for projects evaluated in the mid-1960s to 20-25% for projects evaluated in the mid and late 1970s. By contrast, average rates of return at project completion showed a persistent downtrend for projects appraised during 1970-76 before recovering again for projects appraised around 1980 (and evaluated in 1985-87).

46. The downtrend in average re-estimated rates of return for projects appraised in the early 1970s was most likely due to external circumstances, that is, the recession and low commodity prices at the time these projects were completed in the late 1970s and early 1980s. The increasing rates of

return at appraisal during the 1970s probably reflect Bank-internal factors, including the shift in Bank lending from infrastructure to agriculture and industry. In terms of average outcomes at project completion, the vastly expanded lending program of the 1970s does not compare too unfavorably. Re-estimated rates of return for the 1970s are not very different from those for the 1960s. The sharp increase in re-estimated returns for projects appraised in 1980 must be interpreted with caution, as it includes only a small percentage of projects of that appraisal year.

Figure 2: Rates of Return by Year of Approval



C. Conclusions

47. The statistical analysis of rates of return estimates before and after completion of project construction provides a number of interesting insights. First, it points to the large degree of uncertainty surrounding the rate-of-return estimates. Second, World Bank appraisal estimates of rates of return are biased, that is, too optimistic. If this degree of optimism is

shared by other project evaluators, one should expect that the "discount rate that just rations investment projects to the funds available" exceeds the ex-post rate of return by a considerable margin. The analytical treatment of project risks thus deserves more attention in practice. Anderson and Quiggin (1990), for example, argue that project implementation variables usually enter project analysis on a "no surprises" basis, corresponding to the modal value of the distribution of possible outcomes. Since surprises are mostly unpleasant, the probability distribution of project implementation outcomes is skewed (a longer tail in the downside direction). If one were to allow for the skewed distribution ("bad surprises"), one could correct the bias in the estimate.

48. However, factors that have conventionally been associated with this bias (cost overruns, implementation delays) seem to explain only a very small part of the unexpected changes in project performance (measured by the rate of return gap). Interestingly, uncertainties seem to be higher in the directly productive sectors (agriculture, industry), where rates of return can be altered through external market forces or domestic policy shocks. Rate-of-return estimates seem to be more stable for infrastructure projects.

49. As an alternative to correcting modal estimates of implementation variables for "bad surprises", one could set different minimum rate-of-return criteria for different types of project (e.g. 10% for transport, but 15% for agricultural and industrial projects), based on observed rate-of-return divergences.

50. The analysis also has pointed to the importance of the policy environment for successful project implementation. The "economic management rating" and "price distortion" variables both indicate that project evaluators did not take the adverse effects of poor economic policies at the macroeconomic level sufficiently into account. More puzzling though, is the fact that regional dummy variables also seem to operate partly as economic management variables, and have considerably more explanatory power than direct indicators of the quality of economic management and institutions.

51. The fact that projects in member countries of the French African Community seem to perform almost as well as those in other regions, shows that the high failure rate of projects elsewhere in Sub-Saharan Africa seems to be related primarily to policies and institutions, and not to some deeper and immutable factors. However, the better performance of projects in CFA countries during the 1960 and the 1970s is no guarantee that this will be repeated during the 1980s, as external competitiveness of the CFA zone has considerably deteriorated.

52. The analysis of observed rate-of-return divergences raises more questions than it can answer. The high degree of revealed uncertainty also raises the question whether, and what kind of, improvements in the methodology will contribute to better investment decisions. Cost-benefit analysis remains primarily a tool for the planner, and it shares his achilles heel: the high cost of information in an uncertain world.

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ANNEX

Derivation of Constant Price Project Data

(i) Project cost estimates for World Bank projects are made in current US dollars, since this is the unit of account for the Bank. Appraisal estimates for a project are made on the basis of prevailing prices at the time of appraisal, a forecast of price changes for internationally traded capital goods (in terms of US dollars), and the projected expenditure (disbursement) profile. Project cost estimates also include a physical contingency for unexpected expenditures. Project costs at project completion are, similarly, the sum of annual expenditures in (actual) current prices ("mixed year dollars").

(ii) In periods of unexpectedly high inflation (or for projects with major implementation delays) re-estimated nominal project costs sometimes are substantially higher than appraisal estimates, but real project costs may not have increased at all. To separate nominal from real cost overruns, we derived real (constant price) cost estimates for each project for both appraisal and project completion, by deflating yearly project expenditures with the projected and actual price index for capital goods (the Bank's "Manufactured Unit Value" (MUV) index for exports of manufactured goods of industrial countries).

(iii) While forecasts for the MUV index were available for the past ten years, we did not have earlier forecasts, and had to estimate the price contingency vectors. Visual inspection of price forecasts for the past ten years suggested that the Bank's price forecasts followed an "adaptive expectations" pattern: projections seemed to be based on recent price trends. Several adaptive expectations models were tested, and we found that the projections were best approximated by a five-year moving average adaptive expectations model.

(iv) The first stage prediction of the MUV index was made by calculating the five year moving average:

$$MUV' = [MUV_{t-1} + \ldots + MUV_{t-5}]/5$$

The moving average values (MUV') were then used to calculate the average deviation from the actual value of the index (MUV' - MUV)/MUV and this estimate was used as a correction parameter, ß, in the adaptive expectations model:

$$MUV_t{}^* = MUV'_{t-1} + \beta\ (MUV_{t-1} - MUV'_{t-1}),\ 0<\beta<1$$

That is, the forecasting error for the previous period, $MUV_{t-1} - MUV'_{t-1}$ is corrected with a fraction ß (the average error), thereby improving upon ("adapting to") the first-stage forecast.

(v) The real cost at appraisal price projections, p^a, is then:

$$X^a(p^a) = \sum_{j=1}^{t^a} \frac{c^a/t^a}{p_j{}^a}\text{ , where}$$

X^a = real cost at appraisal
t^a = projected duration of project implementation
c^a = nominal cost estimate at appraisal
$p_j{}^a$ = projected price vector at appraisal

and the real cost at actual prices:

$$X^c(p^c) = \sum_{j=1}^{t^c} \frac{c^c/t^c}{p_j^c}, \text{ where}$$

X^c = real cost based on actual nominal expenditures (c^c), actual implementation duration (t^c), and actual prices (p^c)

(vi) The real cost overrun is then:

$$[X^c(p^c) - X^a(p^c)]/X^a(p^c)$$

and the unexpected inflation, as defined in the paper:

$$[X^a(p^c) - X^a(p^a)]/X^a(p^a)$$

Note that unexpectedly high inflation ($p^c > p^a$) is a negative number according to this definition. This is reflected in the minus sign before the percentage sign in the tables with the statistical results (-%).

Table A1: Actual and Predicted Changes in the MUV Index
1961-1987 (%)

Year	Actual	Predicted /a
1961	1.7	-3.9
1962	2.0	0.7
1963	-1.9	1.3
1964	2.3	0.0
1965	0.6	0.7
1966	3.5	1.0
1967	0.9	1.6
1968	-0.6	1.3
1969	5.2	0.9
1970	6.1	2.5
1971	5.5	3.3
1972	8.9	3.8
1973	16.1	5.7
1974	21.7	9.7
1975	11.2	13.4
1976	1.4	12.7
1977	9.9	10.1
1978	14.9	11.8
1979	13.4	12.1
1980	9.7	10.5
1981	0.5	9.8
1982	-1.4	8.4
1983	-2.5	6.0
1984	-1.7	-3.6
1985	1.1	0.8
1986	18.3	-0.8
1987	10.6	4.9
Mean	5.8	4.6
Standard deviation	6.8	5.0

/a Simulation of Bank forecasts with adaptive expectations model.

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